Beamline Instrumentation Interface Offline Analysis Software

Jake Calcutt

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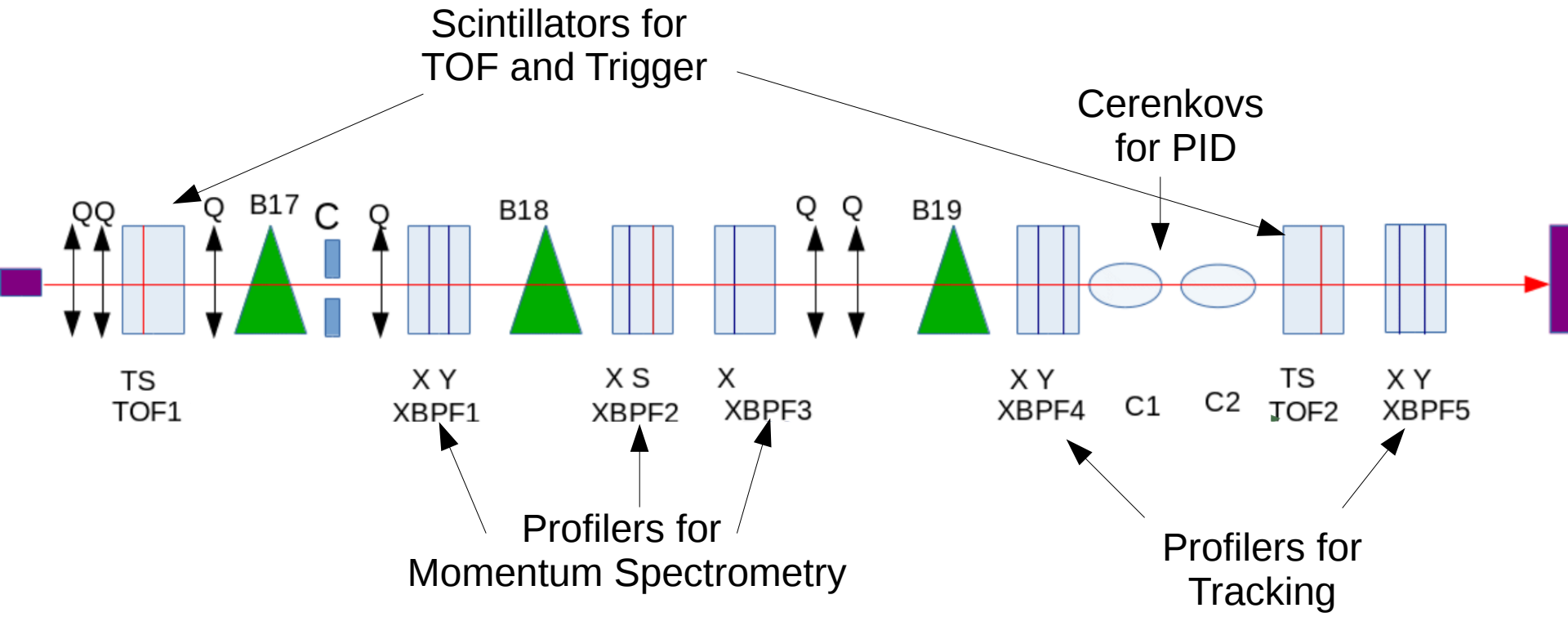
Beamline Instrumentation



Software Goals

- Take art::Event time and extract beam data from IFBeam database
- Decode beam data into a LarSoft product (ProtoDUNEBeamEvent)
- Provide offline analysis (BeamAna_module.cc)
  - Track particles in beamline
  - Measure momentum by curvature
  - PID with Cerenkov Detectors
  - Time of Flight Measurements
  - Matching TPC beam events to tracks in beamline

Current Status

- Can filter out art::Events without triggers from beam activity
  - Requires CTB RawDecoder (See Nuno's talk from yesterday's mtg)
- Grabbing from the IFBeam database with real data
- Matching between events in separate beamline monitors (in coincidence) working
- TOF: Code is there and working
  - Currently receiving input from the wrong scintillator monitor
- Cerenkov: need to go through CTB fragments in the art::Event

Current Status

- Can do tracking with the last 2 Profilers and project to TPC face
  - Need to update the coordinates/tilts of the profilers
  - Currently using coordinates from MC
- Momentum Spectrometry
  - Needs debugging, but have some reasonable first results
- Matching TPC events to specific beamline events not ready
  - Timing info not not ready for this
  - Saving everything within a spill to each event

Filtering For Beam Triggers

- Trigger Board (CTB) receives signals from the various systems (Beam, CRT, SSP)
  - Configured each run to send a trigger to timing system based on which signals it receives
  - Makes decisions on which High Level Trigger word to send (HLT0 → HLT7)
- In BeamAna:
  - Look for the HLT in the event's CTB Fragment
  - Filter out 0 and 5 (Random Trigger and Beam-Excluded, respectively)
  - Save Timestamp for matching with beamline info

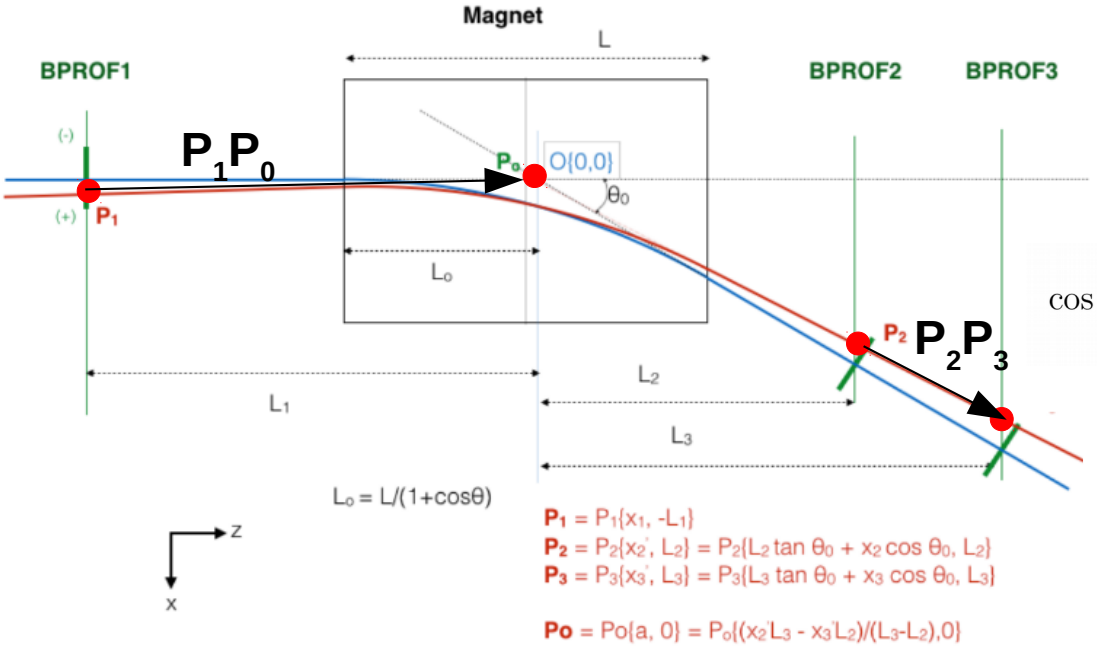
Matching TPC to Beamline

- Beamline Instrumentation and TPC (PDTS) not on the same timing system
  - Different reference points for timestamps
  - Cannot match without knowing how to convert
- Hookups between them are installed
  - BI will receive a signal when the PDTS sends a trigger, and will timestamp this
  - PDTS will receive a signal at the time of the SPS Warning Extraction (WE, immediately before a spill) and will timestamp
  - BI already receiving WE and timestamping
- Difference between PDTS and BI WE gives conversion
  - Need to wait until firmware is ready (“this week”)

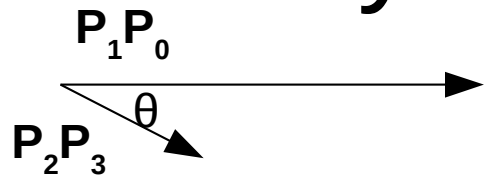
Tracking Beam Particles

- Using last 2 profilers to create recob::Tracks and projecting these into the TPC
- Will be used in the Chao's 3D event displays
- Need to deal with degenerate hits in profilers
- Still no matching to specific events
- Saving tracks from entire spill
  - Still no matching
- No plots in this talk (sorry!)

Momentum Spectrometry



CERN-ACC-NOTE-2016-0052, Charitonidis, N. Karyotakis, Y. Efthymiopoulos, I.



θ_0 (nominal beam angle) transforms from in-profile to global coords

$$\cos\theta = \frac{(a-x_1)(x_3-x_2)\cos\theta_0+(L_3-L_2)(L_1+(a-x_1)\tan\theta_0)}{\sqrt{L_1^2+(a-x_1)^2}\sqrt{(L_3-L_2)^2+[(L_3-L_2)\tan\theta_0+(x_3-x_2)\cos\theta_0]^2}}$$

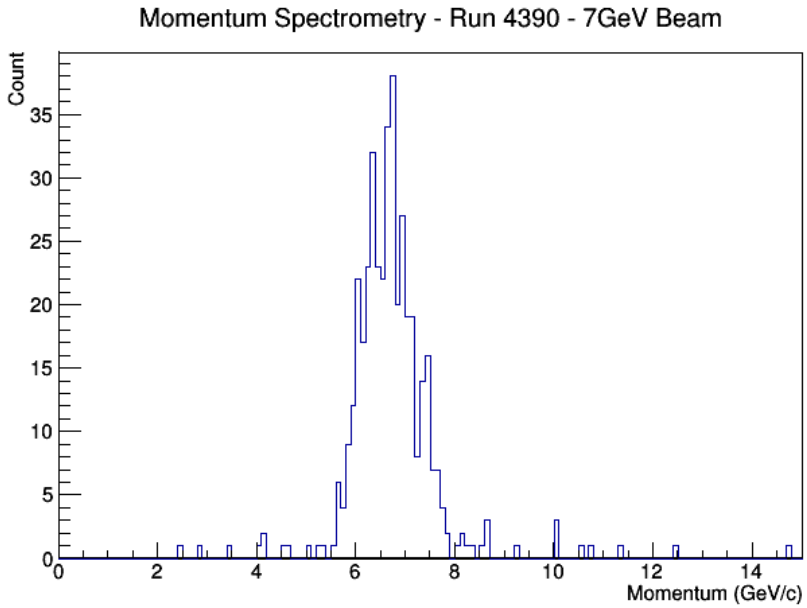
$$a = \frac{x_2L_3-x_3L_2}{L_3-L_2}$$

(Momentum) p = (cLB) / θ

Credit: Alex Booth

Momentum Spectrometry

- Results
  - Run 4390
  - Used Event 1001 to get beam data
  - Information from entire spill
    - No matching to event time



Momentum Spectrometry

- Issues:
  - Can sometimes have multiple hits in a profiler for a given activation
  - Multiple particles in coincidence?
  - Need to figure out how to decide which active fibers to choose

```
At Time: 1537024893
Successfully fetched
Current: 508.3
XBPF022697 has 5 active fibers at time 4.63282e+08
7 8 9 10 89
BPROF1
XBPF022701 has 2 active fibers at time 4.63282e+08
34 79
BPROF2
XBPF022702 has 2 active fibers at time 4.63282e+08
26 145
BPROF3
fBeamBend 0.12003
CosTheta 0.997263
Theta 0.0739974
Momentum: 11.345
```

Time Of Flight

- Grabbing info from 2 scintillator planes
  - Currently at 702m and 716m along beam line
  - The data connection at 702m will eventually be placed on the plane at 687m
- Matching these timestamps to a signal corresponding to a coincidence of these
  - TOF = Δt of these matched timestamps

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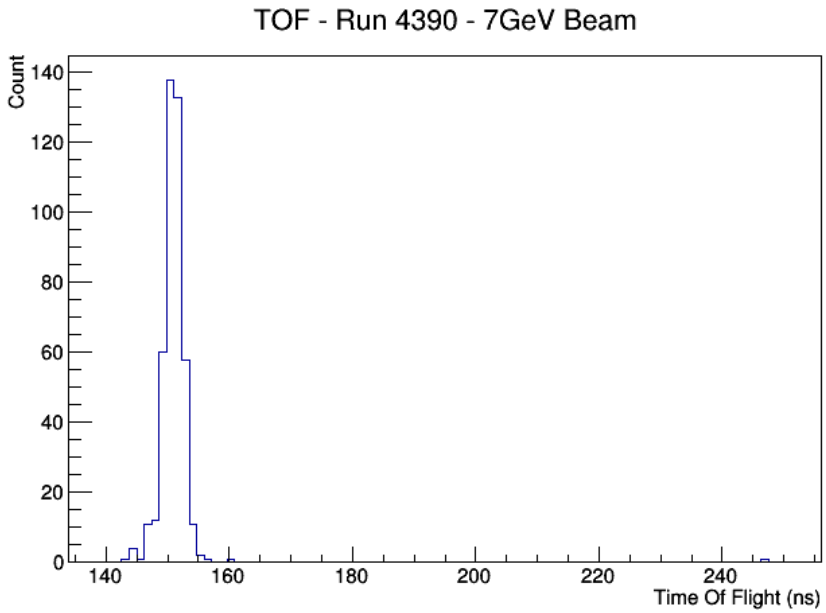
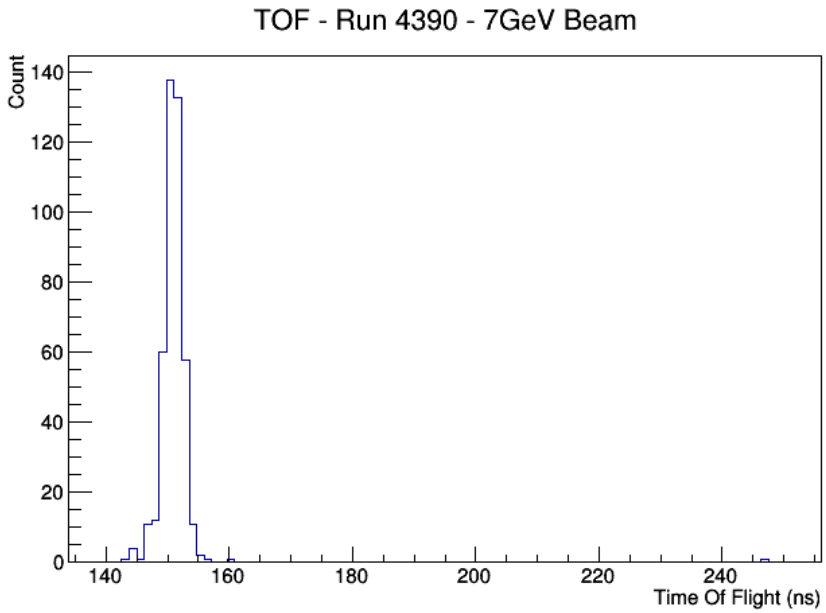


Time Of Flight

- Results
  - ~150ns @ 14m
  - Gives a speed of ~.333c
  - Need to check if there's any clock offset



Cerenkov Detectors

- The Cerenkov detectors only save aggregated rates for:
  - Good particle triggers
  - Triggers in the Cerenkov PMTs
  - Coincidence of these two
- The High Level Trigger words from the CTB can encode this info for each beam trigger
  - Will need some work to include this
- Currently only one Cerenkov detector hooked up

Summary

- Extracting real beam data from IFBeam database
- Can match between devices within beamline in a given spill
  - Need to wait for timing firmware to match to specific events
- Momentum spectrometry seems ‘reasonable’ at first glance
  - What to do about duplicate hits?
- Need to debug TOF values

Summary

- Individual cerenkov triggers aren't saved
  - Need to dig into trigger words from CTB
- Need to update tracking and momentum spectrometry with more accurate coordinates